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The topocentric libration gives the selenographical longitude and latitude of the point on the Moon's surface which occupies the center of the disc, as seen from the Lick Observatory. P. denotes the position-angle of the Moon's axis, reckoned from the apparent circle of declination.*

REVIEW OF SOLAR OBSERVATIONS, 1895 (AUGUST-DECEMBER) AND 1896.

BY DAVID E. HADDEN.

The following solar observations are a continuation of those communicated to the Society for the years 1891 to June, 1895, and published in Vol. VII., No. 45, of the *Publications*.

The instrumental outfit used has remained the same, viz.: a three-inch equatorially mounted telescope, and a grating spectro-scope of 14,438 lines to the inch.

During the year 1896 the appearance and approximate position and size of each sun-spot group and facula have been sketched daily on sheets of paper containing a three-inch ruled circle, divided into quadrants, the east and west line being set parallel with the Sun's apparent motion, by allowing the limb of Sun's image to move tangent to the horizontal spider-line in the eyepiece; the observations are afterward properly corrected for position-angle of the Sun's axis and inclination to the ecliptic. By this means an approximate position of the latitude and longitude is obtained.

Complete observations and detailed descriptions of the results have been published in the *Monthly Review of the Iowa Weather and Crop Service*.

The following tables exhibit the summaries of these observations:—

RESUMÉ OF SOLAR OBSERVATIONS. 1895.

Months.	Number of Observing Days.	Mean Daily Number of		
		Groups.	Spots.	Faculae.
July	3	. .	. .	. .
August	22	4.7	43.9	2.9
September	19	5.1	22.3	2.8
October	20	4.6	35.5	3.3
November	16	3.9	16.2	2.9
December	17	6.3	27.1	2.9

* For a continuation of this article see the *Notices L. O.*

1896.

January	9	3.2	8.5	3.2
February	18	3.8	24.0	2.5
March	16	3.7	14.8	2.6
April	17	3.7	21.8	3.2
May	18	2.3	10.7	2.5
June	16	3.0	23.1	2.3
July	23	3.8	15.1	2.7
August	20	2.2	10.7	2.6
September	17	2.9	31.2	3.3
October	21	2.8	12.9	2.6
November	12	3.6	16.0	3.2
December	10	4.0	24.7	3.6

The steady decline in number of groups and spots noted as having set in during 1894 and the first half of 1895 has continued during the period under review, several days without spots being noted in April, August, and October, 1896. Among the larger and more noteworthy groups observed may be mentioned the following:—

August, 1895.—Several large and interesting groups from 1st to 14th. On the 27th, a fine, single spot, with double umbra, appeared at the east limb and completed the transit of the disc, disappearing at the west limb on September 9th, and reappearing again by rotation at the east limb on September 23d, and once again completing the transit; its umbra was quite interesting from day to day, at times being single, double, round, irregular, and curved. Other large groups were noticed during the closing days of September and fore part of October, and again during the third decade of that month.

On September 24th, a fine, bright protuberance was observed on the east limb.

On October 12th, a large stemmed prominence was on the west limb, near a group which was disappearing by rotation.

On October 20th, faint reversals and distortions of the Ha line were observed on the east edge of the large east group of spots.

November 1st to 9th, large groups and spots dotted the disc.

December 20th to close of the month, a number of fairly large and very interesting groups crossed the disc.

The following synopses of my observations for each month of the year 1896 are reprinted from the *Iowa Monthly Weather Review*:—

January, 1896. Sun-spots were few and small during the month of January, but three groups made the entire transit of the disc from east to west during the period, and nearly twice as many groups were noted in the southern as in the northern hemisphere.

February, 1896. The sun-spots for the first half of February, 1896, were small, but during the latter half two especially fine and interesting groups made the transit of the disc. Twice as many groups were noted in the north as in the south hemisphere in the first half of the month, while during the latter half there was a slight increase in favor of the southern.

March, 1896. The total number of sun-spot groups noted during the month of March, 1896, was about the same as for the preceding month, but they were smaller and contained a less number of spots.

But three groups made the transit of the disc, the remaining groups being of a very transitory character; the average life of all groups visible was 2.8 days per group. A fairly large group appeared on the 26th, but after passing the central meridian about April 1st, it seemed to be fading out in small spots.

April, 1896. The average daily number of sun-spot groups for the month of April, 1896, was about the same as for the preceding three months, but the individual spots were much smaller. But one fairly large group was noticed during the month, namely, on the 10th.

From the 14th—the date of next observation—until the 18th, the Sun's disc was free from dark spots. This is the first time since August, 1891, that the disc has been entirely clear. A minimum also occurred in November, 1895, when a few days were noted in which but one very faint group was present.

From April 20th to 26th the groups were all small and transient.

The average daily number of groups was about the same in both northern and southern hemispheres during the month.

May, 1896. Sun-spots during the first twenty-five days of May, 1896, were few, small, and uninteresting. On the 26th, an extensive group of small spots suddenly appeared, which rapidly increased in size and activity, and at the close of the month was a very conspicuous group of much interest.

Compared with the preceding four months of the year, there was a decided falling-off in the daily average number of groups, spots, and faculæ, evidence of the approaching minimum of solar activity.

June, 1896. Large and interesting groups of spots were visible on the solar disc during the entire month of June, 1896, with the exception of a day or two about the 20th, and the three closing days of the month. The average number of groups was three per day, 2.1 of which were observed in the southern hemisphere. Five groups made the entire transit of the disc, while one originated on the visible side and completed the transit during the month.

July, 1896. Sun-spots for the first eleven and last eight or ten days of July, 1896, were few and small. On the 12th, a large spot appeared at the southeast limb, which completed the transit of the disc and dis-

appeared at the west limb on the 25th. This group was the most important one of the month, and proved quite interesting, undergoing many changes from day to day. Another group appeared on the north-east limb on the 14th with indications of much activity; it rapidly increased in size in the next few days, but had entirely disappeared when near the central meridian on the 20th. As in the preceding two months, the southern hemisphere was the region of greatest frequency of spot groups. But three groups completed the entire transit of the disc from east to west during the month.

August, 1896. The daily average number of sun-spots visible during the month of August, 1896, was the lowest so far in the present year, being but 2.2 per day. Five groups completed the transit of the solar disc from east to west during the month. The principal group of the month appeared by rotation on the 9th—a large, well-defined circular spot with nucleus and penumbra, which changed but little during its transit. On the three closing days of the month, several new and fairly large groups appeared, which were of interest. The southern hemisphere was again the location of greatest frequency of disturbances.

September, 1896. Sun-spots from September 1st to 8th were few and small. On the 9th, a fine extended stream of spots appeared at the east limb and made the transit of the disc. It was one of the longest groups observed in many years; owing to cloudy weather, but few observations of it were possible; before reaching the west limb it rapidly became smaller, the spots breaking up and fading out, not to reappear again by rotation at the east limb. The southern hemisphere continued to be the region of greatest frequency of spot groups during the month.

October, 1896. Sun-spots during the first half of October were very few, no spots being seen on the 5th. From the 18th to the close of the month, several small groups made the transit of the disc. The southern hemisphere continues to be the location of greatest spot frequency.

November, 1896. Sun-spots during the month of November, 1896, were few and small, with the exception of a fairly large and interesting group, which made the transit of the disc from about the 2d to 14th, but of which only a few observations could be obtained, owing to the cloudy weather. As in the preceding six months, the southern hemisphere still continues to be the region of maximum spot frequency.

December, 1896. During the first half of the month of December, 1896, sun-spots were few and unimportant. During the latter half of the month, one group rapidly increased in size and made the transit of the disc, but was on the wane before disappearance at the west limb. The southern hemisphere still continues to be the predominant region of spot disturbances.

Notwithstanding the fact that during the year 1896 the period of minimum of solar activity had set in, several very large and unusually fine groups of spots appeared during the year. A brief description of some of these is given here. A reference number is given to every group each month.

FEBRUARY, 1896.—GROUPS NOS. 11, 14, 15.

February 20. No 11: a small single spot with penumbra near west limb; this was an interesting group, first appeared on 10th at east limb as a couple of small spots, soon enlarged, and was quite conspicuous from 14th to 18th, undergoing many changes from day to day, and passing over the west limb as a small spot again. No. 14: a quite prominent group, three large spots. No. 15: a new, fine, large group on east limb, about twenty degrees south of equator; it consists of a large penumbra, with double nucleus, the nuclei being connected by a narrow line of umbra; the nucleus on west side is crossed by a "bridge"; many faculæ surround the group, and many small spots are in its vicinity.

February 21. No. 14: a train of large spots, with two large leader spots. No. 15: a very fine, large group, still having the nuclei connected by a narrow dark line.

February 23. No. 14: this group is a superb object; it is fully one-tenth of the apparent diameter of the Sun in length, and consists of three fine large spots. Each of the first two spots contains double nuclei, and a "bridge" was noticed crossing a portion of the umbra of the second spot. No. 15 is also a very interesting and superb group; the large leader spot has triangular umbra in nearly round penumbra; this is followed by a larger, somewhat rectangular penumbra containing a series of small spots; many small spots and penumbral matter are also in vicinity. A group of four fine prominences was observed on west limb; one large banyan-tree-like form was quite interesting.

February 24. No. 14: still a fine object; umbrae of both leader spots greatly changed. No. 15: umbra of leader spot also much changed.

February 25. No. 14: about same; umbra of leader spot is getting large. No. 15 is more extensive; is now about on the central meridian; multitude of small spots in its vicinity.

February 26. No. 14: the umbra of the leader spot is still enlarging, and now crossed in center by a narrow "bridge"; this group is yet a fine object. No. 15 also contains a most interesting group; the nucleus of the leader spot is nearly round, and that of the next spot long and narrow, while the third spot contains a somewhat crescent-form nucleus.

MARCH, 1896.—GROUP NO. 21.

March 26. No. 21: a new group of two fine large spots, each with well-developed nucleus and penumbra; the west spot has three nuclei, the east, one with an elongated nucleus. A very extensive facula region appeared by rotation at the east limb.

March 30. No. 21 is now a little east of meridian, and is a little smaller; the leader, or west spot, has extensive penumbra, with one large nucleus and numerous small nuclei; the following spot has divided into two distinct spots, each with penumbra.

APRIL, 1896.—GROUP NO. 8.

April 10. No. 8: this is probably No. 6; it has changed decidedly since last observation. It is a very fine group in the northwest quadrant,

consisting of a large penumbral area, containing a double umbra; a small spot is on following side, its nucleus being crossed by a "bridge"; many small spots are in its vicinity. A "veiled" group was noticed a little east of the central meridian, in south latitude.

MAY, 1896.—GROUP No. 12.

May 26. No. 12: new group of many small spots, which formed since yesterday, little south of equator, about three days from east limb, with slight penumbra around two spots. No. 13: new small spot, east limb.

May 28. No. 12: great activity in this group; it now has a large oval penumbra, with one large and several smaller nuclei; this is followed in immediate vicinity by a number of small spots, some with slight penumbra.

May 29. No. 12 is a fine, much more extensive group to-day. The penumbral area is increasing, but breaking up somewhat; the main nucleus is larger and elongated; a large number of small spots, some with penumbra, are following this group. Much solar disturbance is manifest.

May 30. No. 12 is still a fine group; the nuclei seem to be coalescing; much penumbra surrounds and follows the group.

JUNE, 1896.—GROUPS NOS. 11, 12.

June 24. No. 11: on the central meridian to-day, is increasing much in activity; the leader spot has umbra which appears to be dividing; this is followed by a large area of penumbra and numerous small spots. No. 12: a new group in southwest quadrant, very extensive, containing a large leader spot and followed by many small spots.

June 25. No. 11: new small spots appearing on east side of group. No. 12: about the same as on yesterday, except not as many small spots in vicinity.

June 26. No. 11: the group is breaking up, the leader spot has divided into two parts, each with penumbra; a "bridge" is across the umbra of the large west spot. No. 12: the umbra of leader spot is oval; the penumbra does not entirely surround it, apparently being overlaid by facula on its east side.

June 27. No. 11 is fast diminishing in size and breaking up. No. 12: the leader spot is now on edge of west limb; its nucleus has penumbra on north and south, but not on east or west sides.

June 28. No. 11: only a few spots left, with a trace of penumbra. No. 12: but a dot left on extreme edge of west limb; group disappearing by solar rotation. Very fine prominence was observed on southeast limb at 1:20 P.M.; portions of it attained a high altitude, but at 2:20 P.M. had greatly changed, and at 3:25 P.M. no floating cloud forms were seen, and prominence was more quiescent; also prominences on west limb, one of which was pyramidal in form.

JULY, 1896.—GROUP No. 12.

July 12. No. 12: fine new spot with double umbra on edge of southeast limb, penumbra partially visible on west edge of lower

nucleus, but not on west edge of upper one, and is visible on all other sides of both nuclei. A fine aurora last evening. A bright group of prominences was directly over the group on limb.

AUGUST, 1896.—GROUP No. 13.

August 30. No. 13: a new group on east limb, with two nuclei in large facula. A very fine group of prominences was observed on the west limb at 3 P.M., also smaller one on east limb.

SEPTEMBER, 1896.—GROUP No. 6.

September 11. No. 6: a very fine train of spots well in, on east limb in north latitude; about fifteen nuclei were counted in the extended penumbra; several portions are detached and of a semi-circular form; the group is inclined about fifteen degrees, or more, toward the equator.

September 13. No. 6: this is a magnificent group to-day; it has greatly increased in size, length and interest; fully thirty nuclei are included in the long detached groups of penumbral nebulosity which still has the semi-circular form in numerous portions.

September 16. No. 6: this great group is almost exactly bisected by the central meridian to-day; several transits of the group were taken to estimate its length, which was found to be about 190,000 miles.

September 17. No. 6: the fine group continues about the same, but segmentation of the spots has set in.

September 19. No. 6: the group is breaking up somewhat; the following spots are thinning and fading out.

September 20. No. 6 is now breaking up; it has two irregular penumbral areas, one with a large nucleus and the other containing two nuclei; the smaller spots are fading out.

September 22. No. 6: but a couple of small spots left of this group which is disappearing by solar rotation.

OCTOBER, 1896.—GROUP No. 16.

October 23. No. 16: a spot on extreme edge of east limb, south of equator, near which place, at 11:55 A.M. to 12:30 P.M., an intensely brilliant small prominence was observed; a detailed account of this phenomenon was published in *Popular Astronomy* for December, 1896.

October 24. No. 16: a well-defined, medium-sized spot, with penumbra, which is not visible on west side of umbra yet.

October 25. A very fine group of prominences on west limb; one large, feather-like prominence and several smaller ones; the larger one was fully 90,000 miles in height. See my account of it in *Popular Astronomy* for December, 1896.

NOVEMBER, 1896.—GROUP No. 3.

November 4. No. 3: fine, large spot, one day in, on east limb in south latitude; has a nearly circular penumbra with umbra, the umbra being divided by a semi-circular streak of light.

November 5. No. 3: only a faint streak of light crossing umbra to-day.

November 11. No. 3 is now in southwest quadrant. Cloudy weather prevented any observations of this fine spot since the 5th; the umbra is somewhat oval, and the entire spot larger.

November 12. No. 3: the umbra is more "triangular" in form to-day.

November 13. No. 3: penumbra is not visible on west edge of umbra to-day.

November 14. No. 3: this fine spot is now on edge of west limb; the penumbra is not apparent on either east or west edges of its umbra.

DECEMBER, 1896.—GROUPS NOS. 8, 15.

December 15. No. 8: group of about fifteen small spots a little east of meridian, several having penumbra.

December 18. No. 8 is larger, and consists of five or six spots, with penumbra, some with several nuclei.

December 19. No. 8: three spots have three or more nuclei each; No. 15: minute spots northeast.

December 22. No. 8 is now disappearing at west limb by solar rotation. No. 15 has developed into a fairly large group; has one fine leader-spot, with broken umbra in a somewhat circular penumbra, and followed by a compact group of small spots.

The following table gives the maximum and minimum number of sun-spot groups observed on any day for the months and years indicated:—

Months.	Maximum Daily Number of Sun-spot Groups.		Minimum Daily Number of Sun-spot Groups.	
	1895.	1896.	1895.	1896.
January . . . . .	. .	6	. .	I
February . . . . .	. .	6	. .	I
March . . . . .	. .	5	. .	I
April . . . . .	. .	7	. .	0
May . . . . .	. .	4	. .	I
June . . . . .	. .	5	. .	2
July . . . . .	. .	9	. .	I
August	8	5	2	0
September	9	6	2	I
October	8	6	2	0
November	6	6	I	2
December	11	8	I	2

ALTA, Iowa.—Latitude 42° 40' N.
Longitude 6^h 21^m W.